

***WORKPLACE INNOVATION SCALE: A NEW METHOD  
FOR MEASURING INNOVATION IN THE WORKPLACE***

**Theme:** The Nature of Learning and Knowledge

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## **Abstract**

The production of knowledge in projects in building design can be characterised as an interplay between actors within and across several knowledge intensive companies including consulting engineers, architects and contractors. The product usually combines organisational knowledge stemming from various professional practices into a documentation representing a new building. The organisations operate under continual pressures from structural, organisational, professional and individual sources. The knowledge production consists of a bricolage of practical experiences, formalised information, transformation of demands from external alliances and customer demands.

This paper combines a critique of the knowledge management discourse with contributions on project working and teams. Mainstream knowledge management discourse picture knowledge as either a well-defined tangible entity or describe how it can quickly become one. They also leave the issue of the content of the knowledge blackboxed. Although Community of Practice approaches dismantle the rationalistic perceptions of knowledge, a belief of the stability and non-political, 'power free' features of the knowledge production is maintained. And they still leave out the content issue. It is suggested to view the knowledge production as relying on temporary network building, knowledge alliances, in and across teams in the projects and the companies.

The paper presents an ethnographic case study of a building design process. Several management initiatives in the involved companies address the production and management of knowledge. These managerial initiatives can be seen as an attempt to develop the internal resources as much as possible. However they occur under a continual regime of 'getting things done' in the ongoing project, very often with the project as 'the winner' on behalf of others in the battle of resources and attention by the project managers and employees. It is illustrated how the projects are carried out under continual stress and with restricted room for collective reflexivity.

We discuss through the empirical material, barriers for the knowledge production in building design which includes: group polarization, group thinking, power and politics, time pressure and the structure of the design process. It turns out that an important knowledge type to be handled is coordination- knowledge between various technical/professional areas, across projects and across companies. The empirical case presented shows how these domains continually are in tension with each other making coordinative knowledge political.

Keywords: Design, Community of Practice, knowledge, coordination, construction

## **Introduction - the fragmentation of building design**

In construction certain narratives are usually mobilised to explain how management and organisation occurs. It is thus an often celebrated sectorial myth (interpreted here as a part of the sectorial symbolic culture (Alvesson 1993)), that the inter-organisational cooperation is temporary. The belief is that knowledge production in building design is closely related to realising 'one of a kind' productions. This is illustrated in the ever changing context of building projects. The location of the construction site is unique and the building owner and stakeholders vary from project to project. However when focusing on a single project and institutional links it will occur that the temporary element is relaxed. It appears rather to be a network of recurring partners in different constellations, with rather well defined and well-exercised roles that is in play. (Loosemore & Tan 2000b) analyses these as stereotypes.

A central characteristic is the organization of the supply chain which exhibits a specific division of labour and institutionalized roles such as the manufacturers of the basic part, building companies (including craftsmen), engineering companies and architects. This differentiation of the institutions is developed and sustained by the educational system. In one perspective building design is an art; a major discipline of architecture; something ambitious young people learn at Royal Academies of Fine Art. In a somewhat contrary perspective building design is also a matter of professional practice, of production, dissemination and application of knowledge; something that professionals of the more down-to-earth no-nonsense variety, might find can only be learned in The School of Life.

Although there are examples of transcending these institutionalized roles they are generally maintained in the majority of building projects. Consequently every project is organised cross-organisational, thus making the knowledge production in the project an inter-organisational task. This cross-organisational setting is maintained in the design process as it usually encompasses collaboration with a set of actors including architects, various engineers and other professions.

Drawing on (Alvesson 2002) and (Wenger 1998), (Thuesen & Koch 2003) shows that the landscape of cultures in the project setting can be interpreted as a multiple configuration of Communities of Practices (CoPs) characterised by overlapping and partly shared practices and individuals with multiple memberships of communities with different levels of participation. The interplay between the CoPs is established in arenas by boundary objects and brokers. In other words CoPs are interwoven within and across organisational boundaries between companies, projects and professions.

This fragmented characteristic is of major importance when discussing the production and management of knowledge in building design. The product of the design process combines knowledge stemming from these various professional practices into a documentation representing a new building. This includes areas as mechanical and electrical engineering, building physics, project and construction management. The knowledge developed within the project group consists of a bricolage of practical experiences and formalised information.

The problem we address in this paper is to understand which problems and barriers there exist for developing knowledge in building design, given the fragmentation of design process. Furthermore we attempt to illustrate how these barriers might be overcome by coordinating knowledge.

The perspective we here are taking are the knowledge production in heterogeneous project groups – a perspective which usually isn't discussed in traditional literature with exceptions as (Garrick & Clegg 1999; Keegan & Turner 2003; Newell et al. 2002). Recently (Bresnen et al. 2003) discusses the management of knowledge in project environments. They however focus on an organisational level while our ambition is to study the project in detail by conducting an ethnographic field research.

The paper opens with a description of the theoretical base: knowledge production in heterogeneous groups. Subsequently follows some methodological considerations. Then a case study is presented with an identification of barriers for developing knowledge. An example of coordination knowledge is presented and is discussed as a tool for overcoming the barriers. Ultimately the paper is closed by a conclusion winding up headlines of the paper.

## **Theory – knowledge production in heterogeneous groups**

Theories on knowledge and learning have traditionally focused on how to support processes by systems and technologies with a tendency to view culture as a blackbox. Gradually the role of

cultures has however come into play, especially with the introduction of the notion of Community of Practice (CoP). We endorse the importance of a cultural approach to management of knowledge and organisational learning, as an understanding of how knowledge is “working” at a micro level is a foundation for creating successful knowledge initiatives. Theoretically we therefore draw on organisational culture, CoPs and organisational politics as three main schools of thought.

We initially open with a discussion of theories handling knowledge production, followed by an outline of characteristics of heterogeneous groups ending up in a discussion of developing knowledge in heterogeneous groups – focusing on the coordination of knowledge.

## **Knowledge production**

Concepts like ‘Knowledge Management’ and ‘Organizational Learning’ has been a subject of increasing interest during the last decades. This development has been dominated by discourses with central figures as Nonaka, Davenport and Von Krogh. We will not present a review of these positions here but point to (Stacey 2001) who offers a substantial critique of the main discourses of knowledge and learning in his identification of 10 taken for granted assumptions with the split between the individual and the social being the most prevalent assumption.

During the development there has been a shift from a structural to a processual approach with an increased focus on aspects as culture and practice. (Gibbons et al. 1994) distinguish this turn from mode 1 to mode 2. Our approach stems from the second tradition. In the second mode practice and knowledge are seen as inseparable which has given (Polanyi 1966)s statement, that knowledge always have an unarticulated component – “the tacit dimension”, a renaissance.

One of the most influential contributions to the mode 2 discourse is the concept of Community of Practice developed by (Brown & Duguid 1991;Brown & Duguid 2000;Lave & Wenger 1991;Wenger 1998;Wenger, McDermott, & Snyder 2002) and numerous commentators/adopters. According to (Wenger, McDermott, & Snyder 2002) a CoP “...is a group of people who interact, learn together, build relationships and in the process develop a sense of belonging and mutual commitment.” (p. 34).

Its noticeable that recent development in cultural studies (Alvesson 2002) and CoP have a lot in common, where the theme ‘shared meaning’ is central in both symbolistic organisational culture understanding (Alvesson 1995) and in CoP (Wenger 1998). Both are e.g. drawing on the work of (Bourdieu 1979) and his concept “Social fields”. In (Alvesson 2002)s development of the “*multiple cultural configuration view*” (p. 190) he states that organisations can be understood as shaping local versions of a broader societal and locally developed cultures in a multitude of ways. People are to different degrees connected with organisation, suborganisational units, professions, projects, gender etc. Cultures (interpreted here as CoP) overlap in organisational settings, and are rarely tightly connected to the social structures of the organisation. This is very much in line with (Brown & Duguid 1991)s suggestion that organizations can be seen as a web of CoPs canonical as well as noncanonical - often with the noncanonical practices as the main sources of innovation.

Practice is the foundation for transferring knowledge, as knowledge in mode 2 is seen as something socially constructed and contextual. A basic requirement for sharing knowledge between people is therefore a presence of a shared practice (Wenger, McDermott, & Snyder 2002). (Knorr-Cetina 1999) identifies this prerequisite in her work with epistemic cultures

and (Brown & Duguid 1998; Brown & Duguid 2001) uses this to explain the sticky and leaky nature of knowledge as they states that “knowledge...runs on rails laid by practice” (p. 204). The creation of knowledge has been a subject of interest as it is seen as a source of innovation and thereby a necessity for survival in competitive markets. One of the most influential theories here is Nonakas SECI-model where knowledge is created through an iterative process of converting tacit to explicit knowledge through the phases Socialization, Externalization, Combination and Internalization (see e.g. Nonaka 1998). The foundation of this process is an enabling context which they term *ba* and which facilitates interactions. In contrast to this model (Brown & Duguid 1998) sees the creation of knowledge more from a ecology perspective believing that CoPs is the main source for creation of knowledge. (Cohen 1998) points to the similarities between Nonakas originating *ba* and Browns ecology system as they both emphasis the creation of knowledge within a complex unified organic system (p. 28). Resent critique of the SEIC model (e.g. Brown & Duguid 2001) has pointed out that Nonakas division of knowledge into explicit and implicit not harmonises with (Polanyi 1966)s understanding that these just are *dimensions* of knowledge. While the CoP approach accepts this announcement it is still naive to believe that CoPs only is a source of innovation as they by there shared practices and ‘taken for granted assumptions’ can grow in to be very conservative (Brown & Duguid 1998; Newell et al. 2002).

## **Heterogeneous groups**

Most mainstream literature including the concept of CoP does however not discuss the issue of handling knowledge in heterogeneous groups. Etienne Wenger studies in his significant book from 1998, a group of claim processors who work in fairly stable context. Recalling the discussion in the introduction a project group in our context is a collection of many different practices put together in order to solve a specified task (in our case designing a building). This draws our attention to theories dealing with temporary systems.

According to (Goodman & Goodman 1976) a temporary system as “a set of diversely skilled people working together on a complex task over a limited period of time” (p. 494). (Meyerson, Weick, & Kramer 1996) elaborates on this definition and states that temporary groups are characterised by performing tasks with high degree of complexity and lack of formal structures that facilitate coordination and control. Furthermore they depend on an elaborated body of collective knowledge and diverse skills and they often entail high-risk and high-stake outcomes (p. 167). Another key characteristic according to (Meyerson, Weick, & Kramer 1996) is the mutual dependency of the participating partners. This stems from a division of labour where each subtask is dependent of another due to the complexity of the general process.

From a CoP approach a temporary system can be seen as a collection of multiple interdependent communities with different practices that might overlap in the organisational setting. While there are differences in practice between these communities they also to some extend share some practice, which enables communication across the boundaries. Drawing on (Thuesen & Koch 2003) a temporary system might in other words be interpreted as a multiple configuration of CoPs.

## **Knowledge production in heterogeneous project groups – coordinating knowledge**

As heterogeneous project groups are characterised by diversity rather than homogeneity the members are initially likely to have more in common with their colleagues in their organisations than with the others in the project. The diversity of such groups makes it possible to carry out a complex task due to the division of labour. A central condition for success is the organisation of knowledge (Brown & Duguid 1998) by how different competencies are assigned the project (Newell, Robertson, Scarbrough, & Swan 2002). As stated previously a shared practice (including a common language) is however a requirement for developing knowledge as it enables the flow of knowledge within the group.

In the division of labour there is a tradition on focusing on the input and output of the sub processes, with a focus on minimizing the overlap between the processes based on the idea that the optimal use of the labours absorptive capacity (Cohen & Levinthal 1990). This approach however fails when unforeseen events arises. As this is everyday life in temporary systems the standardization and description of boundaries between practices is replaced by overlapping practices in order to cope with the emergent nature of the project.

This implies that the struggle in a project is a balance between diversity and homogeneity – a mingling with competencies. The shared practice is needed in order to facilitate the flow of knowledge and the diversity for solving a complex task without making everyone in the group know everything. (Iansiti 1993) discussed this balance by using the T-form as metaphor for illustrating the depth of a particular knowledge area combined with a general understanding of other disciplines. Though his perspective stems from an individual point of view we find it applicable to CoPs, as the domain which the community is gathered around can be seen as the depth knowledge area.

As the output of the knowledge production in heterogeneous project groups should be characterised by consistency between the areas the coordination of knowledge is of outmost importance. Especially between successive tasks in a ‘production process’ the coordination of knowledge seems critical due to the interdependence between the tasks.

In our view *coordination knowledge* is the ‘knowledge work’ in the boundaries between CoPs, based on the interdependence between the practices in a project. The knowledge areas are coordinated through interactions in terms of dialogs and negotiations and are highly dependent of the context due to the situated nature of knowledge.

(Alvesson 2002) touches this aspect from a cultural theory perspective by identifying that an organisation must develop some degree of mutual understanding in order to deal with problems and make collaboration possible. He talks about bounded ambiguity. Even if cultures does not produce clarity and consensus it can offer guidelines for coping with ambiguous meanings, giving clues on how to deal with tricky issues.

In the process of carrying out the task the project can be interpreted as a domain in (Wenger, McDermott, & Snyder 2002) universe<sup>1</sup> which are tying people together. Through mutual engagement in this domain they form a community (p. 33), develop a shared practice (p. 37) and create identity. Regarding the diversity the project group might turn into a CoP – a boundary practice (Wenger 1998 p. 114). The coordination of knowledge takes place as each member of the project is brokering by legitimate peripheral participation in the project and the community which they are a part of ‘at home’. Furthermore boundary objects (Star & Griesemer 1989; Wenger 1998) connect the different practices within the group and generate new understandings in both groups as they negotiate the meaning of the object. Through this coordination the boundary object might become a part of the shared practice in the group.

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<sup>1</sup> Three elements characterises a CoP. These are further developments of the dimensions in (Wenger 1998) with a strong coherence between; (1) the domain and the joint enterprise, (2) the community and the mutual engagement and (3) the shared practice and the shared repertoire.

This is very much in line the concept “cultural traffic” describing the interaction between and shaping of cultural manifestations (Alvesson 2002). This concept is important since it explains why cultures are not fixed entities but evolves over time.

(Wenger 1998) demonstrates how two CoPs can mutually strengthen each other in everyday practices but downplays the possibility that such deep embedding introduces ambiguity and tensions. The result of this effect is that two CoPs might be in conflict with each other, or even constitute themselves on a stereotypic image of ‘the others’ – a phenomenon well described in organisational culture literature (Alvesson 1993). This suggests that the cultural approach is supplemented political approach viewing the production of knowledge as relying on temporary network building (coalitions), exercise of power, and related to exploiting rooms for manoeuvre along with opportunities, problem settings, boundary buildings and solution formulations.

(Lazega 1992) describes the micro politics of knowledge production in groups as he develops the notion “knowledge claims” illustrating the dynamic and controversial interplay between different world views. He distinguishes between four types of claims the realistic, the expert, the polemical and the initiated, based on an understanding of how they are legitimized and endorsed in a group (p. 54). Though his focus is on the relation between individuals in the setting we find it applicable from a perspective on practices and cultures.

Stephen Fox illustrates the power dimension by synthesizing Actor Network Theory and CoP theory on the basis of (Foucault 1984) conception of power “...as an active resistive or reactive force” (Fox 2000 p. 861). Here decisions are created through a process of persuasion, linking humans and artefacts.

Based on these positions we suggest viewing the knowledge production in a heterogeneous project group as a mingling with competencies, coordinating knowledge relying on shared practices, temporary network building and knowledge alliances, in and across teams in the projects and the companies.

## Method

The methodical approach is multidisciplinary tying together engineering, interpretive sociology, organisation theories and management. In particular we are drawing on analytical strategies from anthropological (Lave & Wenger 1991; Wenger 1998) and organisational culture perspectives, as we adopt a position similar to (Alvesson 2002) who observes that culture studies have to be carried out in a specific context, where its impossible to operate with an entirely stable set of concepts independent of setting.

The case material stems from an ongoing ethnographic study of a construction process focusing on the design phase. Over a period of 6 months one of the authors (Thuesen) was on a daily basis present in the project following in the ‘main’ project activities, covering all the design meetings, workshops, and some internal and external meetings. Apart from participant observation seven interviews of members has so far been conducted including one double interview. Furthermore the formal documents created by the actors have been available to us. After a period of ‘just being around’ in the field the design meetings was taped with accept from the participants. To adopt such a time span was necessary in order to create a familiarity of the researcher. Similar the interviews were conducted after one month with the same argument. The participant observation developed a basis for carrying out interviews around some of the respondent’s tangible experiences raising the quality of the interview by digging deeper.

In order to create an overview of the design process and how knowledge was developed a manuscript of the design process has been created stemming from the empirical material.

Here central events and activities were positioned on a timeline with link to the collected empirical material.

As the research project is sponsored by a contractor we admit that it might create a pro-company bias. We however attempt to mobilise a critical distance to outbalance the pre-given empathy with the company. Additionally it can also be noted that both authors share the professional background as engineers with a multidisciplinary education and training in management and organisation. A potential occupational bias from the authors towards the players in constructions is recognised, but not analysed, see (Loosemore & Tan 2000a).

In an effort to minimise the bias the empirical material has been juxtaposed with material from a forthcoming study of the same building project (Nielsen & Apelgren 2003). Furthermore interpretations have been discussed with the people in the field.

## **Case**

We will here present a case from the construction industry for illustrating the barriers for developing knowledge in heterogeneous projects groups. Furthermore we will illustrate the concept of coordination knowledge. Initially we will though shortly outline the context in order to comply with (Garrick & Clegg 1999)s statement that there in the discussion of project learning has been to little focus on this aspect.

## **The context**

The case is an ongoing partnering project with the aim of developing the schools of a municipality which includes refurbishment of four existing schools. The main actors in the project are besides the architect, a technical consultant and a contractor. The contractor has composed a team which includes a project leader, a design leader and a couple of procurement managers. The technical consultant has four specialists from different departments assigned. Besides these specialist they have assigned a project leader and draws regularly on other competencies in house. The architect has several people working on the project including one project leader. We here follow a design process of the refurbishment of one of the schools.

The main office is located at the construction site of one of the schools and consists of a large open office housing all the members of the contractor (excluding craftsmen). The persons from the architect and technical consultant are not a part of this environment. They work in open offices at their companies' home bases. Most of the meetings are however held at the main office.

The contract describes the different areas of responsibility and as a part of the partnering concept there has been established an incentive agreement in order to ensure that the project runs within a target budget. It exists however only for the contractor while the architect and engineering consultant is waged on their basis of the projects turnover. This means that they have an economical incentive for expanding the budget of the project by drawing as expensive as possible and they only have an ethical responsibility for keeping the 'design' within the budget.

## **The production of knowledge in building design**

The production of knowledge through this design process involves the different professions for the participating companies mentioned above. Each practice is responsible for their part of the design through the division of labour. The architect is designing the building according to aesthetical and functional ideals, gradually detailing it down to dimensions of centimetres. The engineers are taking care of the stability of the constructions, the water, heating, ventilation, electrical and IT infrastructure. Finally the contractor is responsible for managing the budget as they are economical responsible for the project. Furthermore they have a motivation for ensuring the buildability of the design.

The design process in the case is formally split in different phases separated by milestones – a way of structuring the process which seems to be a tradition in the sector. After winning the tender, which were setting some constraints on economy and time, the design team gathered knowledge about customer wishes through a series of meetings. These wishes were incorporated in a project proposal, which the customer had to accept prior to the next phase ‘the main project’ where the detailed design was produced. Based on the outcome of this phase the school is currently refurbished as the formal documentation has been handed over to the craftsmen and contracts were signed with subcontractors.

When studying the process in detail it reveals to be much more dynamic – characterised by overlaps between the phases and practices and a highly iterative nature. An example of such overlaps is when ‘design questions’ arises during the production, requiring the presence of architects and engineers. Although the assigned responsibilities to the practices seem clear, people are keen to help other practices if they can contribute with valuable knowledge. The design process is however not only characterised by harmony and collaboration as clashes of interests and world views of knowledge claims constantly evolves, are negotiated and rise again.

Initially the architects worked on the design with a minimum of constraints by creating sketches of the ideas. Constraints were applied during the process by negotiations as the pool of knowledge grew and the design of the ideas was increasing in details. Gradually the other practices came in play synchronising their knowledge areas with the overall idea in an iterative process getting closer to the final description.

Most of the design occurred at the home bases of the practices drawing on a bricolage of practical experiences from previously projects, formalised information, knowledge about the customer etc. The formal output of these activities like drawings, calculations, notes, summaries etc. were continually developed and put together after each phases constituting a foundation for the customer to review the project. At regularly design meetings facilitated by the design leader the different practices came in play presenting and synchronizing their work. The representation of each practice was usually sustained by one person functioning as a broker between the design group and the home base. In a larger perspective these persons are of critical importance sustaining the flow of knowledge between the professions.

The design meetings followed a rather well defined structure focusing on the development of the formalized knowledge base in order to reach the milestones. Besides topics as economic, schedule etc. the different professions had their own bullet on the agenda. Unfortunately they occurred rather late which caused that most of the time was used discussing other things than the actual design. Repeatedly the architects and the engineers expressed their frustration about this.

It was however not only at these meeting the professions interacted. It also occurred by using email, faxes and phone calls. But as the professions though physical were separated they seldom arranged other meetings automatically. When they however were together the coordination of knowledge was striking.

The flow of knowledge between professions relied on a shared practice in the group. The practice consists of tools, vocabulary, phrases, solutions, understandings etc. The existing of such practices was shown as 'Thuesen' as an outsider, had a hard time trying to understand a part of the rhetoric. The shared practice is created on the basis of the institutionalized practice in the sector and is developed through out the project by e.g. creating new words and adding them to the shared vocabulary. An example of this was the use of the word 'the music' referring to a new building housing the facilities for teaching in music and performances.

Through the ongoing mutual engagement the design group is gradually developed into a CoP. The trend is seen in this project but it is the stories from previous projects, which tells us that it's possible to develop CoP within a project team across organisational boundaries. The CoPs from previous projects turns into networks as the mutual engagement is decreased. These networks of practice (Brown & Duguid 2001) played an important role in the current project but were often hidden. That the previously projects matters was illustrated in a double interview with two procurement managers from the contractor. They stated that if this project group only contained members from the previous project, they wouldn't have to worry about the emptying of the dishwasher, the parking of the cars out side the office etc. – they formed a community.

The faith of the project group is that the hard established CoP is abandoned, as new projects are requiring the competencies and thereby the people. The history repeats itself in the next project.

### ***Barriers and tensions for creating knowledge in building design***

We here attempt to describe barriers and tensions for the development of knowledge in building design based on the current empirical material. Due to limitations of the material this is not a total mapping of the area, but will give an idea of problems which influences the knowledge production.

### **Polarization - separated learning environments**

In this case the different practices participating in the design are placed at different locations. The created learning environments in these companies boost the differentiation of practices due to the amount and quality of the interactions. Even the technical consultants are sitting on different locations and departments and rarely talk to each other outside the design meetings. Narratives are shared of competitors and the practices and persons from the participating organisations. Thereby the local CoPs are strengthening due to the cultural traffic. In this separation of practices the project and customer might be the overall loser if the knowledge between the practices isn't coordinated. (Newell et al. 2002) discusses the downsides of group polarization.

The polarization of the project group is however not only negative as it to some extend are a necessity for accomplishing the complex task of designing a building. Due to the division of labour there exists a mutual dependence between the professions as the work in one practice is dependent of another. The following statement from the design leader is an example of the dependence, the context is a drifted schedule and the architect has a hard time reaching the deadline.

Design leader: *"...If we according to our plan are going to have the smallest hope for starting the 1st. of February – and that's damn close – then there exist some things which needs to be completed. It is not particularly smart for any of us, if we have to sign a contract with a subcontractor and then he can only work temporally in a small area and then we have*

*to negotiate with another one later. That's going to be a mess from an economical perspective..."*

The interdependence makes the design group vulnerable to substitution of members especially the brokers tying the multifaceted landscape of practice together are critical. It was shown in the case as the broker representing the architects temporary were replaced by another. This was contributing to the delay in the time schedule.

## **Group thinking**

The opposite problem of the polarization of the group is the group thinking that might occur. This is also discussed in (Newell et al. 2002). The problem is that the group doesn't question the solutions they have proposed since the solutions through negotiations have become taken-for-granted.

The traditional way of minimizing this problem is by an investigation where the solutions are renegotiated e.g. by the use of an external person being able to question the taken for granted. Another way of minimizing the problem is by setting the right team from the beginning based on the assumption that if the knowledge not is present from the start it won't be used. As a design leader in another context once stated "*nobody knows what they don't know*".

This is also related to the problem of 'reinventing the wheel' which seems to one of the most discussed problems in the struggle of managing knowledge. According to (Bresnen et al. 2003) the capturing and diffusing of knowledge between projects is a major problem as 'the wheel' tends to be reinvented in projects from an organisational perspective.

The traditional way of solving this problem is by using IT systems in an effort to capture the experiences. The problems unfortunately arise as knowledge is socially constructed and highly contextual. But in practice lessons learned do not disappear after the finalization of a project as it is spread together with the people as they are assigned new projects. Combining this with strategies for employee retention, people create an enormous web of contacts. These networks are astonishing stimulating the flow of knowledge in the organisation. But they also create an influential informal organisation which is setting a political agenda in the organisations.

## **Power and politics**

At the project level diversity of the group and the interdependence enables the use of power and politics. Power is exercised where there room for it in terms of dependence. This is illustrated in the flowing example from a status meeting where the options for catching up with the drifted schedule were discussed.

Project leader: "*...If status is that nobody is finished then there is something which we need to prioritize. So forget everything about a carpenter at this moment. Then I start at the school, and then it's me who without exception decides what happens when we're talking refurbishment of doors and windows. Because if we aren't finished then there is only me to do it as I'm responsible for the production. It is similar with the painter. But if we don't want to end up in Armageddon then there is something like glass walls which have a fairly long delivery time. We need to complete the design on elements like that...*"

The political dimension is illustrated in the creation of knowledge claims in the boundaries between the practices. Here coalitions are formed 'in situ' based on the shared practices. This was e.g. the case between the contractor and the project leader from the technical consultant as they both shared a practice in planning expertise which often positioned them on the same side in discussions. These coalitions were also formed outside the meetings as people were

negotiating strategies for supporting their perspective. This implied that the contractor initially was accused by the architects for playing with secret agendas.

### **Restricted time for reflection**

Another problem that influences the production of knowledge is the restricted time for reflection. In this case it is stressed further due to the drifted schedule. This was illustrated by one of the architects regularly complains about the endless queue of meetings.

The battle of resources in the project leaves no room for collective reflectiveness as the project demands the resources, pressing the time schedule and requiring the architects to force. Under these circumstances the project becomes a somewhat constraining condition for learning and organising knowledge, and managerial initiatives under the banner of knowledge management have difficulties overcoming the barriers created by the project logic.

This is very much in line with (Keegan & Turner 2003)s identification of barriers to organizational learning. These include lack of time and reflection at the level of the project team, the tendency to centralize learning and the deferral of learning to future points in time and space. (p.83)

### **Structure of the process**

The last barrier for developing knowledge is the structure of the design process. There is a strong emphasis on the separation of work and in the design meetings the actual design activities are playing an inferior role due to the systematic agenda. Though the formal process only leaves little room for mutual design activities the meetings often unintentional develops into several sub meetings focusing on different subjects where people are coordinating knowledge. These breakouts are hunted down by the design leader.

The structure of the overall construction process is today characterised by the division of labour and people are leaving the project group when their subtask is done. This continual substitution in the project group makes collection of experiences challenging. It further results in an almost non-existing flow of knowledge up in the value chain. This means that people don't see the consequences of their decisions.

Therefore there exist a potential for rethinking the organisation of the process, enabling the use of experiences from the craftsmen by incorporating them earlier in the design process – ensuring the buildability, coordinating knowledge up the stream.

### ***The coordination of knowledge in practice***

We will here illustrate the concept of coordination knowledge, by using a transcription from the previously mentioned status meeting with the presence of the three participating companies. In the actual situation an architect, a 'water and heating' (W&H) engineer, an electrical engineer, the design leader and the project leader participates.

As the deadline for the project has drifted the contractor convened to this meeting in order identify how far the different professions are from finishing their work. The project leader prioritizes the tasks based on his experiences specifying what needs to be done in order to start the actual production on schedule. In that context he is mentioning the refurbishment of the floor patching the linoleum.

## Transcription

- 1 W&H engineer: *Discussing the linoleum, there exist some minor borderline cases where we have to break up the floor.*  
Design leader: *Yes*  
W&H engineer: *and if I have to describe it e.g. "under" the plumber then I'll describe*
- 5 *that it's him who are going to break it up and pour in concrete ... (he is interrupted)*  
Project leader: *but you shouldn't do that*  
W&H engineer: (he continues) *... up to the underside of the linoleum*  
Architect: *We're making...* (he is interrupted)  
Project leader: *Then you just have to write that the breaking up is carried out by one*
- 10 *craftsman and the linoleum work is carried out by another.*  
Architect: *We're making some outline drawings ... (he is interrupted)*  
W&H engineer: *but how do we then explain what the different craftsmen have to do?*  
Architect: (he continues) *... try and listen.*  
W&H Engineer: *Yes*
- 15 Architect: *We're making outline drawings for the ceiling and floor at the whole school when we e.g. are removing some walls. If there besides this are some places where you know there are changes then you can give your input to these plans.*  
W&H engineer: *well okay, it then appears from my current drawings where the craftsmen are going to patch the linoleum.*
- 20 Architect: *Yes, but it can be difficult for us to foresee the consequences of what you have drawn, right?*  
W&H engineer: *Yes, yes*  
Architect: *so when we have made the outline drawings (he is interrupted), that's something Charles (another architect) takes care of.*  
W&H Engineer: (appear elated) *Then the drawings need to be coordinated with me.*
- 25 Architect: *Then these drawings show what should be done in each room.*  
Project leader: *and we have a similar problem with you (he address the electrical engineer), at least in one place.*  
Electrical engineer: *Yes, it's the main electrical panel which is moved.*  
Project leader: *It's the main electrical panel we are talking about. Here we also need to break up the floor and patch the linoleum.*

## Analysis

(1-5) The W&H engineer mentions a problem about the border between two work procedures patching the floor when he is removing an existing a refrigerator on his drawings. He suggests that he solves it by describing that the plumber does the patching.

(6-10) The project leader opposes this solution as he states that the break up of the floor is carried out by one craftsman and the patching of the linoleum is done by another. This also show the extreme division of labour where the relatively simple process requires the participation of two different professions.

(12) The W&H engineer however doesn't see how the work is going to be split.

(15-17) After the architect has tried to make himself heard in a couple of situations he finally are allowed. He proposes as a solution using a boundary object which he is responsible for –

the sealing and floor drawings. Here the architects are describing the areas where the floor needs to be patched when e.g. a wall is removed. He purposes that the W&H engineer gives his input to these drawings.

(18-19) The W&H engineer gets the idea and relates it to his own work and practice.

(20) The architect point out that they can't estimate the consequences of what the W&H engineer has drawn showing the differences in practices.

(21) The W&H engineer acknowledges this statement.

(22-23) The architect state to himself that these drawings need to be produced at home.

(24) The W&H engineer is exhilarated over the solution and repeats it in relation to his work.

(25) The architect put the solution in perspective to the planning of the production represented by the project leader as the tool can be used for describing what needs to be done in each room.

(26-29) The project leader project the solution from one practice to another as the electrical engineer has a similar problem. The electrical engineer knows which case he is talking about, as this has been negotiated at another meeting prior to this one.

It is noticeable that the boundary object solving this problem comes from an unexpected profession as the architect suggests that they just place it on his drawings of the sealing and floor. It should also be noticed that the architect tries to make himself heard without success (line 6 - 15). This might be interpreted as they intentional are holding him out of the conversation. It is however more likely that they don't expect him to be able to contribute to their discussion. But in fact he is the facilitator of the coordination as he recognizes how his work is suitable for solving a problem outside his practice.

We here see an example of the insight in other member's areas - a shared practice as an enabler for coordinating knowledge. But it also requires a mutual accept of each other illustrated in this example by the architect proposing the solution even tough it won't make his life easier.

Situations like these occur time and again and it is symptomatic that only a part of the group is participating in the coordination session due to the dependences in the design team. The coordination in this example is characterised by harmony between the professions. Usually it is however influenced by power and politics and takes form as a negation between the different world views. This might lower the motivation for actually participating in the coordination.

When asked two months later the architect and engineer didn't remember this situation and the solution weren't implemented as the architect and engineers were drawing their details on separate drawings. Although it was a good idea the reason why it didn't succeeded should be seen in the light of the separated working environments and that the situation wasn't followed up. The solution could have become part of the shared repertoire and thereby been used at the other schools.

## **Discussion: coordination knowledge in a larger perspective**

(Bucciarelli 2002)s research has focused on the nature of design. One of his significant contributions is the notion of 'Object Worlds', which can be interpreted similar as a part of a shared practice. Each person is having his own collection of objects and is to some extend sharing them with others in the design team. In this context the object world can be related to the project, companies and profession and coordinating knowledge is about relating objects from different worlds by using a proper language.

(Borland & Tenkasi 1995) in (Newell et al. 2002) highlights the idea of coordinating knowledge, saying that “the problem of integration of knowledge ... is a problem of perspective taking in which the unique thought worlds of different communities of knowing are made visible and accessible to others.” (p. 130). Coordination knowledge is in other words created by working together getting insight in other practices and object worlds.

We will here emphasize the role of arenas as contexts where the coordination of knowledge takes place gathering the practices by legitimized peripheral participation of brokers. The coordination of knowledge is furthermore boosted by informative boundary objects (Thuesen & Koch 2003).

In relation to the problems and barriers for the production of knowledge in the design process the coordination of knowledge can be seen as a resource for repairing these problems except from the power and politic issue. Coordination knowledge is about finding the right balance between polarization and group thinking balancing between diversity and homogeneity. Coordination knowledge is about organising knowledge, drawing upon the right competencies within as well as outside the group.

The coordination knowledge varies from context to context e.g. due to the uniqueness of projects. There is though also a repetitive element based on the traditional overlap between practices e.g. between the architect and construction engineer which requires a coordination of knowledge. This means that the design leader on one hand needs to ensure repetitive coordination areas but also needs to be aware of situations which occur unexpectedly. It is a managerial challenge to chase these situations of coordinating knowledge and continually follow up on them. Furthermore he needs an overview over the dependence of the areas which isn't a part of the project group and thereby be able to position them within the larger constellation of practices. This requires insight and experience from the design leader coordinating knowledge, catching up the situated nature of knowledge, acting as a facilitator – orchestrating the practices.

It is however not only a matter of centralised leadership from the design leader as the coordination of knowledge also has an individualistic perspective. The individual needs to pay attention to the areas where his competencies is valuable and should be encouraged to actively play the game of coordinating knowledge. This idea is central in self managing teams (Molleman 2000).

We have to focus on the creating environments and procedures which enable coordination of knowledge. This can be done by splitting the design meetings up in several sub meetings letting people do the design in smaller groups letting the leaders from the companies constitute a coordination group aligning the different practices. The meetings could with advantage be arranged around themes instead of professions enabling the practices to dispose their competencies. The themes could be identified on the basis of the initially produced specification but should be developed throughout the design process. An example could be an area as the indoor climate which would at least require the presence from the architects and the ventilation engineer.

Coordinating knowledge in the design process is however also an aspect of drawing on the competencies and experiences from the craftsmen. This means we try to overcome the barriers sustained by the traditional contracts where the craftsmen are drawn in the project when it is too late.

Spending more time designing together, talking about perspectives, coordinating knowledge, creating room for collective reflection, is key characteristics for stimulating project based learning creating a shared practice through the value chain.

## Conclusion

Winding up, this paper has attempted to illustrate how knowledge is developed in the heterogeneous project groups. This seems especially important to understand in the light of the increased focus on the customer, which is prevailing in many industries today. While there indeed is a potential for developing practices in the participating companies in a project, it might be a sub-optimization from the customer perspective, as development of a shared practice in the project is neglected.

The empirical case presented shows how the domains of professions, project and company are in tension with each other, making coordinative knowledge political. We have identified barriers for the knowledge production in building design which includes: group polarization, group thinking, power and politics, time pressure and the structure of the design process. Except from the power and politics we have illustrated how coordinating knowledge can act as a tool for sorting out these barriers. By coordination knowledge we understand the knowledge work in the boundaries between practices synchronizing their work in order to reach more robust solutions.

We find that coordination knowledge is a concept worthwhile chasing in the context of heterogeneous project groups, as an understanding of the synchronization of knowledge between practices. It is a foundation for the act of balancing between developing specialist competences and a shared practice – the balance between diversity and homogeneity.

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